Vol. V. JANUARY, 1889. No. 9.

# American Meteorological Journal.

A Monthly Review of Meteorology, Medical Climatology, and Geography.

## TABLE OF CONTENTS.



***NOTE.—This Journal offers prizes for the best studies of tornadoes. Competition closes July 1st, 1889. For particulars send to Mr. Harrington, at Ann Arbor, for special circular.***

ANN ARBOR, MICH., U. S. A.:

METEOROLOGICAL JOURNAL COMPANY.

19, 21 and 23 Huron Street.

F. A. BROCKHAUS, Leipsic, Berlin, and Vienna, Agent for German and Austrian States.

**Single Copies, 25 cents. Per Annum, $2.00. In European Countries, $2.25.**

Entered at the Ann Arbor Postoffice as Second Class Matter.

THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. V. ANN ARBOR, JANUARY, 1889. NO. 9.

# ORIGINAL ARTICLES.

## TORNADOES AND DERECHOS.

[CONCLUDED.]

BY DR. GUSTAVUS HINRICHS,
Director Iowa Weather Service.

### REAL TORNADOES IN IOWA.

65. I have endeavored to make an authentic list of the tornadoes that have actually occurred in Iowa during the existence of our Iowa Weather Service, and give the result below.

The unfriendly interference of the Signal Service has greatly hindered this, as well as all parts of the work of our Service, as I shall be compelled to show at another time.

66. I shall divide the tornadoes into two classes, namely, *multiple* and *single* tornadoes. To these must be added the division of *minor and doubtful tornadoes.*

The first two classes, therefore, comprise very nearly all authentic tornadoes of real importance, while even the genuine tornadoes in the second division are of no more consequence in their destructive effects than a thunderstorm. Indeed, lightning alone does more damage to life and property in Iowa than the tornadoes.

67. The notable tornadoes I shall again divide into *large* and *small* tornadoes. It is only the large tornadoes that can be con-

sidered calamities, and may be compared to natural convulsions in other parts of the world, such as floods, earthquakes, and the like. Only three such tornadoes have occurred in Iowa during the thirteen years of the operation of our Iowa Weather Service.

68. The following table will therefore exhibit our general classification of tornadoes:

| | | | |
|---|---|---|---|
| A. *Notable Tornadoes.* | | | |
| | Class I. *Multiple Tornadoes.* | | (7) |
| | | a, Large Tornadoes. | (3) |
| | | b, Small Tornadoes. | (4) |
| | Class II. *Single Tornadoes.* | | (9) |
| | | a, Large Tornadoes. | (1) |
| | | b, Small Tornadoes. | (8) |
| B. *Minor and Doubtful Tornadoes.* | | | (14) |

69. From the number added in parentheses it appears that only 7 multiple and 9 single notable tornadoes have occurred in Iowa during the last thirteen years, and that the total number of minor and doubtful tornadoes which all are practically harmless was 14.

We may therefore say that the real tornado frequency of Iowa has averaged one a year, and that of harmless and doubtful phenomena of this kind also one a year has been reported.

70. Finley gives 107 tornadoes for these thirteen years, or nearly eight a year, which is four times as many as our notable and doubtful together.

Our record averaging one real tornado a year is bad enough, and needs no amplification by professional tornado manufacturers.

We shall now first give our chronological list, and thereafter divers classified lists for special study.

71. *Notable Tornadoes in Iowa, from 1875 to 1888.*

The character of the tornado is indicated as follows: I, Multiple; II, Single: a, Large, b, Small.

1878.—April 21, Boyer and Maple Valley tornadoes. I, a.
June 1, Adair and Floyd Co. I, b.
October 8, Monticello tornado. II, b.
October 15, Sac Co. tornado. II, b.

1880.—April 18, Davis Co. I, b.
June 5, Muscatine Co. II, b.
June 9, Wheeler's Grove tornado. II, a.
June 14, Cass Co. II, b.

1881.—June 11, Polk and Hancock Co. I, b.

1882.—April 8, Story Co. II, b.
April 18, Davis Co. II, b.
June 17, Grinnell tornado. I, a.
October 30, Scott Co. II, b.

1883.—June 11, Brush Creek tornado. II, b.

1884.—July 4, Woodbury, Crawford and Hardin Co. tornadoes. I, b.

1886.—April 14, Nishnabottany Valley tornadoes (or Coon Rapids tornado). I, a.

72. To this list may be added as authenticated the following three older tornadoes:

May 24, 1859, Johnson Co. II, b.
June 3, 1860, Clinton Co. II, a. Comanche tornado.
May 22, 1873, Washington Co. II, a.

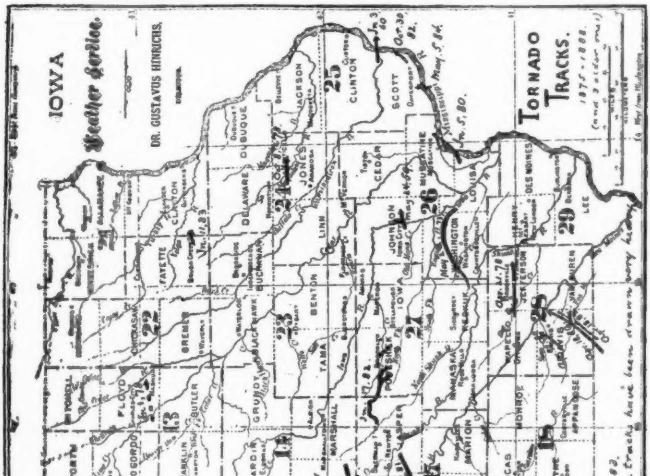
73. The following comprises the minor and doubtful tornadoes, which are all of no importance:

May 18, 1877, Shelby Co. A hailstorm. (?)
May 19, 1879, Jackson Co. Not a tornado.
May 30, 1879, Page Co.
July 2, 1879, Plymouth Co.
June 24, 1880, Kossuth Co.
May 13, 1881, Benton Co.
June 12, 1881, Jefferson Co.
October 28, 1881, Oskaloosa.
June 24, 1882, Kossuth Co.
April 23, 1883, Maple Valley.
May 9, 1883, Linn Co.
September 3, 1883, Mechanicsville.
September 3, 1883, Webster Co. Hailstorm. (?)
May 5, 1884, Davenport tornado.

These are either insignificant (as is the last), or other phenomena than tornadoes.

74. The tornado map here given represents the tracks of all notable tornadoes, so far as I have been able to locate the same. In considering this map it should be borne in mind that the breadth of the printed line is of necessity vastly in excess of

the destructive path of the tornadoes, and also, that along these lines the at times very considerable lengths during which the




tornado did not reach to the ground (was intermittent) are drawn in full also. In other words, even our own map gives for

these two reasons unavoidably a greatly exaggerated view of the tornado tracks in our State of Iowa. This map, in size 13 by 19 inches, was exhibited in MS. at the Iowa State Fair in 1886. See Report for 1886, pp. 7–9; Exhibit No. 7.

75. All of the notable tornadoes will be found mentioned or described in our Bulletins and Reports of the Iowa Weather Service. The most complete description, with six maps, has been issued separately, in 1879, for the storm of Easter Sunday, April 21, 1878, comprising the Boyer and Maple River Valley tornadoes and the Jefferson county tornado of that date. This description will also be part of No. 4 of the Report for 1878.

More complete descriptions I expect to be able to publish in connection with the next Biennial Report.

76. It will be interesting to give a *classified list* of the notable Iowa tornadoes. I include the three old tornadoes of § 72.

I. MULTIPLE TORNADOES.

A. *Large.* April 21, 1878, Boyer and Maple River Valley tornadoes
June 17, 1882, Grinnell tornado.
April 14, 1886, Nishnabottany Valley tornadoes.

B. *Small.* June 1, 1878, Adair and Floyd Co.
April 18, 1880, Davis Co.
June 11, 1881, Polk and Hancock Co.
July 4, 1884, Woodbury, Crawford and Hardin Co.
(Really minor tornadoes.)

II. SINGLE TORNADOES.

A. *Large.* (June 3, 1860, Clinton Co., or Comanche tornado.
May 22, 1873, Washington Co.)
June 9, 1880, Wheeler's Grove tornado.

B. *Small.* (May 24, 1859, Johnson Co.)
October 8, 1878, Monticello tornado.
October 15, 1878, Sac Co.
June 5, 1880, Muscatine Co.
June 14, 1880, Cass Co.
April 8, 1882, Story Co.
April 18, 1882, Davis Co.
October 30, 1882, Scott Co.
June 11, 1883, Brush Creek tornado.

77. It will be noticed that the most serious of all tornadoes, namely, the *large multiple tornadoes*, have occurred at intervals

of four years, namely, in 1878, 1882, and 1886. At this rate the next destructive phenomenon of this kind would be due in 1890, either about the middle of April or June. But we hope that the interval may prove much longer this time.

78. Arranged by *years*, we find four tornadoes each for 1878, 1880, and 1882, and only one each for 1881, 1883 1884, and 1886, while none have been recorded for 1879, 1885, 1887, and 1888.

79. A much longer series of observations must be had before any inference can be drawn from this table beyond the mere statement of fact that the year 1880, flanked by 1878 and 1882, has been the middle of a maximum of tornado frequency in Iowa, while the last few years have been remarkably free from these dreadful storms.

80. Arranged by *months and dates*, we find the following results:

April: 8, '82; 14, '86; 18, '80, '82; 21, '78.
May: (22, '73; 24, '59. Only old cases.)
June: 1, '78; 5, '80; 9, '80; 11, '81, '83; 14, '80; 17, '82.
July: 4, '84. (Minor tornadoes.)
September: None notable, only one minor, on Sept. 3, 1883.
October: 8, ,78; 15, '78; 30, '82.

81. Omitting the dates of *minor tornadoes*, so-called, we may strike the months of May and September from those in which, during the last thirteen years, notable tornadoes have occurred in Iowa. Indeed, it seems that *September may be definitely stricken off from the Iowa tornado months*, while the two cases 1859 and 1873, as well as the number of minor tornadoes that have occurred in May (see § 73), leaves May as a month of tornado danger for Iowa.

82. It is proper to put the July 4th tornadoes into the list of minor tornadoes, so far as all of Iowa with the exception of the northwest is concerned.

83. With these facts before us, and having reference only to the last thirteen years, we may say that *the tornado danger in Iowa is restricted to the three months of April, June, and October*, and is in the ratio of 5 to 7 to 3 for these months. That is, of notable tornadoes, 5 occurred in April, 7 in June, and 3 in

October, or 15 in all, not counting the minor and doubtful tornadoes.

84. The tornado danger in Iowa is four times as great during the rising season as during the falling season; for April and June have had 12 tornadoes, while October has had but 3.

85. Large multiple tornadoes have occurred only during the rising season; namely, two in April (1878 and 1886), and one in June (1882).

86. The large tornadoes, both multiple and single, have all occurred during the rising season. In fact, all October tornado tracks have been short.

87. Our people of Iowa should bear in mind that there are really but *two* months of the year in which the tornado danger is at all serious, namely, April and June, and that the danger in these two months is almost equal. It is true, June counts a greater number (7) than April (5), but the most extended multiple tornadoes have occurred in April, fully balancing the greater frequency of June.

88. The only other month of the year in which real tornadoes may be looked for in Iowa is October, and as to frequency it is but one-half that of each of the other months, and as to extent and power of the tornado, it is still less in the fall season.

89. There remains a tornado danger attachad to May, but during the last dozen of years it has been marked by only minor or doubtful phenomena of this kind.

90. Lastly, it may be interesting to ascertain, whether or not any predilection for special *dates* can be recognized.

We find *one* tornado for the 1st, 5th, 9th, 15th, 17th, 21st, and 30th, each, and *two* tornadoes for each of the following dates, namely, the 8th, 11th, 14th, and 18th. For the other nineteen dates we find no entry at all.

91. It will be noticed that the four dates, 14th–15th and 17th–18th, comprise almost half the notable tornadoes that have occurred in Iowa during the last dozen years; it will also be seen that they are the two days immediately preceding and following the mid-month, the 16th.

The secondary danger dates are the 8th and 11th.

92. The experience of the past thirteen years allows us to recognize two sets of dates as showing the greatest tornado danger in Iowa, namely: 1st, The mid-month dates, from the 14th to the 18th, on either side of the thus far harmless 16th; and, 2d, At the close of the first and beginning of the second decade we have the three danger dates of the 8th, 9th, and 11th.

93. We may also express the same facts in the following words:

The greatest tornado danger in Iowa falls on dates terminating in *one* (1, 11, 21) and *eight* (8, 18); the tornado danger of dates terminating in 4 (14) and 5 (5, 15) is only half as great; while the tornado danger of dates in 7 (17) and 8 (8, 18), 9 (9) and 0 (30), is again only half of the latter. We have had no notable tornado in Iowa on a date terminating in either 2, 3, or 6.

I give this form only for the sake of completeness; the expression in the preceding paragraph is the more rational and by far the most useful.

94. In the light of all the facts presented here, we may say that the tornado danger in Iowa is greatest about the middle of April, June, and October; that from the 8th to the 11th of these months we have a marked secondary period of tornado danger; and finally, that outside of these periods, the tornado danger in Iowa is but small.

95. My results in regard to tornado tracks, tornado predictions, and rules of safety, will, of necessity, have to be passed by this time, the extent of the present paper having already become too great.

96. In concluding, for the present, the consideration of this most important and interesting question of meteorology, I would request those who almost entirely control and domineer this science in America, and who receive unlimited aid from all branches of the Government, to stop the manufacture of dire tornadoes, and thus free their published records from the stain of absolute untrustworthiness that now makes them useless.

97. It was to me a matter of duty to science and to our people to wipe out that immense body of fiction and error which forms the bulk of the tornado lists issued by and under the

authority of the Signal Service. What remains of storm and disaster is surely bad enough—though our State of Iowa in such calamitous disturbances of nature is not more afflicted than other parts of the world. The very cause of the tornadoes we find in the benign elements of heat and moisture that make our State and the great Mississippi Valley the grandest garden of the world. It is when these elements, by the sudden increase of intensity, have come into an unstable equilibrium, that the derecho and tornado take their rise, and suddenly, under manifestations of dreadful power, break this unstable condition and again make the benign, stable conditions return, and in a short time blot out the marks of destruction.

## THE ORGANIZATION OF THE METEOROLOGICAL SERVICE IN SOME OF THE PRINCIPAL COUNTRIES OF EUROPE.

BY A. LAWRENCE ROTCH,

Member of the German Meteorological Society, and Fellow of the Royal (London) Meteorological Society.

### FRANCE.

*History.*—The study of meteorology in France was first organized by Le Verrier, at the Paris Observatory. The storm of November 14, 1854, known as the "Balaclava" storm, which assailed the allied fleets in the Black Sea, showed the necessity and the possibility of a regular service of storm warnings for the protection of maritime interests. From the year 1856, thirteen stations scattered through France sent daily a meteorological telegram to the Paris Observatory, and eleven others sent their observations by post, while neighboring countries began to send observations also. About the year 1857 these data were first published in the *International Bulletin*, which has appeared daily since January 1, 1858. The earliest attempt at warnings to the sea-ports dates from 1860, and in 1863 was published in the *Bulletin* the first synoptic chart with the atmospheric conditions over Europe.

Le Verrier, therefore, has the honor of first using in Europe

the telegraph for the dissemination of weather information for the benefit of shipping. Under date April 4, 1860, he wrote to the Astronomer Royal of England: "To note a storm as soon as it appears in Europe, to follow its course by the telegraph, and to inform in season the coasts which it may reach, such should be the object of our organization." On and after August 12, 1863, Le Verrier not only telegraphed facts but also forecasts of the weather. One of his last acts was the extension of the agricultural service over France. This service was established by a decree of February 13, 1873, and in 1876 the first agricultural despatches were sent to three Departments. Notices which are useful to the agriculturist are different from those which concern the navigator. The former is interested in the occurrence of frosts, thunderstorms, rain and hail, while generally the wind is of little consequence. The agricultural notices contained the barometer readings at a few stations, and the general state of the weather.

In 1861, Le Verrier proposed that the study of the oceans should be divided among the nations, and in furtherance of this plan the Paris Observatory published for 1864–5 a series of daily synoptic charts for the North Atlantic Ocean, under the title *Atlas des Mouvements généraux de l'Atmosphère.*

Previous to 1864 there existed no connection between the observers scattered throughout France. In this year Le Verrier, with the approval of the Minister of Public Instruction, invited the Councils-general to establish observing stations at the Normal Schools. This proposal was favorably received, and most of the Councils voted the necessary funds to establish meteorological stations at the schools. A further development soon followed, by the establishment of Departmental Commissions, composed chiefly of professional men, whose duty it was to collect all observations made in their Departments, and to forward them to the Paris Observatory, and later to undertake the first inspection of the stations, and to superintend the publication of the observations made in their respective Departments. In 1865 the special study of thunderstorms was begun, and additional observers were found among the priests, physicians, teachers,

and others, no instruments being required. The results of these observations were published in the *Atlas des Orages de l'année 1865*, and in the *Atlas Météorologique, 1866–76*. The study of thunderstorms led the Observatory to extend its investigations to rainfall, and in 1869 it had already collected rainfall observations at 436 stations in France, established for the most part by the corps of engineers.

The meteorological work of the Observatory at this time was subdivided into (1) the study of the general movements of the atmosphere, and (2) the general physics of the various basins in France, and the organization of the Departmental Commissions engaged in this work. After the death of Le Verrier, in 1877, the meteorological service of the National Observatory was separated from the astronomical work by the decree of May 14, 1878, and a distinct meteorological service, under the name of the Central Meteorological Office, was created, with Prof. E. Mascart at its head.

*Organization.*—The system consists of the Central Meteorological Office, under the ministry of Public Instruction, with which co-operate a number of observatories, the Normal Schools and the Departmental Commissions. The principal observatories with self-registering instruments which co-operate with the Central Office, besides its observatory in the Park of St. Maur, are: Nantes, Perpignan, the mountain stations on the Pic du Midi, (2,859 m.) and the Puy de Dôme (1,467 m.) with its plain station, the private observatory at St. Martin de Hinx, and the astronomical-meteorological observatories at Nice, Toulouse, Lyons, Marseilles, and Bordeaux. There are about 86 Normal Schools (one generally for each Department), having the series of direct reading instruments, i. e., barometer, air and earth thermometers, psychrometer, rain-gauge, wind-vane, and, if possible, an anemometer, and making three to six observations daily, 22 lighthouses, a few forts, such as the high stations of Servance and Briançon, and about 20 other stations which send monthly observations to the Central Office, where they are checked, reduced and discussed for the climatological service.

All but six of the Departments have organized Meteorological

Commissions, under the supervision of the prefects, composed of the engineers, professors, etc., who encourage local observations, collect and send them monthly to Paris. The Commissions organize the thunderstorm observations in the Departments, and in general direct all the meteorological work of their districts. Their delegates attend a general meeting of the council of the Central Office once a year for the purpose of examining the progress and requirements of the Commissions. The Central Office supplies verified instruments to the Commissions, which are mostly self-supporting, but are sometimes aided by the Office. Many Commissions publish bulletins of their work. The minimum number of stations observing rain and temperature in each Department should be 10, and of stations observing rain only, 30, including the preceding. The actual number of the former class is about 400, and they are equipped with maximum and minimum thermometers and a rain-gauge (sometimes a barometer, also), and make wind and cloud observations. The 2,000 rain stations have only rain-gauges, but observe wind and clouds. For the observations of thunderstorms there are other observers (road-masters, etc.,) to the number of 3,000, who have simple rain-gauges, and transmit their observations monthly to the prefect of the Department. The Hydrological and Forest Services aid in observing thunderstorms, at about 1,000 stations. There are about 2,000 phenological stations. Except at the observatories the observers are not paid; most of them belong to the public service, except at the Normal Schools, where the observations are made by the scholars who are to become teachers. At the stations of the third order some remuneration is granted in certain cases to the observers by the Meteorological Commissions.

The war vessels and a large number of merchant ships formerly made the simultaneous observations for the United States Signal Office. The observations made on board merchant ships are collected at the principal ports by a special staff, which also undertakes the comparison of the instruments. Such agencies exist at Havre, St. Lazare, Marseilles and Bordeaux. In 1887 sixteen gold medals were awarded for the best log-books re-

ceived, as an encouragement to observers on board ship. The observations made in the French colonies are collected by the Consuls and sent to the Central Office.

THE CENTRAL METEOROLOGICAL OFFICE.

The Central Meteorological Office has three departments:

(1) Warnings to sea-ports and for the benefit of agriculture. This branch draws up forecasts and the daily weather reports, and discusses the thunderstorm observations and the forecasts.

(2) Climatology. This branch is charged with the organization and superintendence of the stations and the observatories, undertakes the inspections, and publishes the meteorological observations and various memoirs bearing more particularly upon climatology.

(3) General meteorology. This branch is charged with the organization of observations at sea, at the consulates, and in the French colonies, and studies more especially general meteorological questions.

The staff of the Central Meteorological Office consists of a director, three heads of service, and of adjuncts and assistants. It has the assistance of a Council composed of delegates of various ministries and of the Academy of Sciences. This Council meets every three months. The director calls a meeting of the heads of service every month, at which scientific questions are discussed. The Central Office is in permanent relation with the Meteorological Commissions. The Office is managed by the director, with the assistance of a responsible secretary. The stations are inspected either by the director, by the head of the climatological service, or by one of the staff charged with a temporary mission. The observations are checked on their arrival at the Office, and are compared with each other. The observers are at once notified of doubtful or erroneous observations. The headqnarters of the service was transferred in October, 1887, from the Rue de Grenelle to 176 Rue de l'Université, a government building, which will be fitted up for the service in the most complete manner.

*Weather Telegraphy.*—The telegraphic weather service has

these duties: (1) The receipt of observations from international and domestic stations, which form the basis for the construction of the charts of the *International Bulletin*. The observations are published in the same *Bulletin*. (2) The transmission of forecasts to the ports. (3) The transmission of agricultural forecasts to Communes which have subscribed for them. (4) The transmission of storm warnings to the Ministry of Marine.

Paris serves as the central station of Europe, and such reports (about 38 in number) as are needed by other countries to make up their weather bulletins are sent to them daily. Morning and evening reports are received from 125 stations, including 41 French, 9 Algerian, 9 German, 7 English, 8 Austrian, 10 Spanish and Portuguese, 10 Italian, 5 Belgian and Dutch, 10 Scandinavian, and 13 Russian stations, besides Monaco, Berne, and Constantinople. The hours of observation vary from 7 to 8 A. M. and from 6 to 9 P. M. Certain stations also report at 2 P. M., but are not included in the *Bulletin*. The morning observations and those of the preceding evening are received at Paris in the morning, contained in six-place groups of figures, according to the international cipher code (see explanation in article on the "Deutsche Seewarte"). The observations are deciphered and entered on five charts, one for pressure at the morning observation and change since the evening before, one for temperature and change, one with precipitation since the evening, one for wind, and one for state of weather and sea. From the afternoon reports three charts are constructed.

At noon the probable winds, together with some data concerning the distribution and changes of pressure, are sent to 85 ports, divided into five coasts districts, including Algeria. At 5 P. M. a second despatch is sent, and these telegrams are posted where they can be consulted by seamen. At noon, also, another despatch, giving the probable weather in eighty districts, goes to about 3,000 Departmental Communes, which can subscribe at 40 francs a year if they provide a person to receive and post the predictions and a simple aneroid barometer. In some Departments where there is an observatory, charts are constructed with the barometric data, and local predictions are made. The per-

centage of verification of the forecasts reached in 1887 the high figure of 90. In 1881, local verifications of the forecasts gave 77 per cent., while the success estimated by the Central Office was 82. The storm signals displayed at 73 French coast stations are similar to the British. Warnings are sent to Vienna, Brussels, St. Petersburg, Stockholm, Christiani, and Madrid, if the storm is likely to reach the coasts receiving warnings from these centers. In 1884 the percentage of warnings completely or partially verified at the French stations was 76, and in 1885, 77.

The *International Bulletin* is published daily except Sunday, and is now in its thirty-second year. From January 1, 1858, to May 31, 1878, it was published by the Paris Observatory. Since the reorganization of the service in 1878, it has been issued by the Central Office in an enlarged form. The subscription price is 36 francs a year, and the edition is 500 copies, of which 200 are distributed gratis. It is issued about 5 P. M., and is sent out by the evening post. The data for the *Bulletin* are drawn with lithographic ink on paper, at the Central Office, transferred to the lithographic stone, and printed on blue base maps at the printing office. The *Bulletin* is a folio sheet, and contains on its first and fourth pages the morning observations and those of the preceding evening at the stations before enumerated. The morning reports give the barometer reduced to 0° and sea-level (for the mountain stations the actual barometer also), and the variation in 24 hours; the thermometer and its variation; direction and force (0–9) of wind; state of weather and sea; precipitation; maximum and minimum temperatures in 24 hours. Reports of the preceding evening give the reduced barometer, the thermometer, wind and weather. The detailed observations at the Park of St. Maur are published here. On the inside pages are two charts of Europe, one with the isobars for each 5 mm., and lines of equal variation since the previous evening, while the state of the weather and sea, the wind direction and force, are represented by conventional symbols; the other chart has the isotherms for each 5° C., the lines of equal temperature change, the precipitation (conventional symbols for each 5 mm.), and the thunderstorms since the preceding evening. Below is a

summary of the weather conditions, the maritime forecasts (wind direction and force) for the five districts, including Algeria, and the agricultural forecasts (wind direction, weather and temperature), for the eight districts. Daily despatches from the U. S. Signal Service giving the position of the areas of maximum and minimum pressure over the United States, reports from two Canadian stations, together with certain marine and other telegrams and reports from stations omitted in the last *Bulletin*, complete its contents.

The summary of the weather is published by about twenty-five newspapers, and the Paris *Temps* prints each evening the morning weather chart. Some of the railway companies issue weather bulletins similar in form to that of the Central Office.

*Publications.*—The Central Office has published annually since 1877 the *Annals du Bureau Central Météorologique de France*, in four 4to. volumes. For 1877 the third volume only was published, and commencing with 1885 the *Annals* will be complete in three volumes. Each year is made up thus: Vol. I, *Thunderstorms in France, and various Memoirs.* These include memoirs on the weather service, on thunderstorms, and on questions relating to weather forecasts, as well as papers by meteorologists, whether they belong to the Office or not. Vol. II, *French Observations and Climatological Review.* Daily observations at 23 observatories and stations of the second order in France and Algeria, in the international form, and annual summaries for about 120 stations, were published in 1882. There is also a climatological review, with charts of the chief characteristics of each month in the west of Europe. Vol. III, *Rainfall in France.* This volume contains daily observations at some 900 stations, and monthly and annual totals at about 1,800 stations. A general summary, with discussions of wet periods and rainfall charts, accompany the tables. Vol. IV, *General Meteorology.* This volume contains discussions on the distribution of the meteorological elements over the surface of the globe, and memoirs upon general subjects. In 1880 it comprised the atlas of the North Atlantic winds by Captain Brault, which

supplemented the work of Maury. From 1882 it contains observations from the French consulates and colonies.

Since January 1, 1884, the *Monthly Bulletin* has been separated from the *Monthly International Bulletin.* It appears about two months after the observations which it contains are closed, and contains a general summary of the weather in Europe and detailed summaries from ten French observatories.

*Staff and Budget.*— Prof. E. Mascart is the director; M. E. Fron has charge of the department of weather forecasts and storm warnings; M. A. Angot is at the head of the climatological service; and M. L. Teisserenc de Bort directs the general meteorological work. The staff is divided into titular meteorologists, adjuncts and assistants. The former receive from 3,000 to 10,000 francs a year, the second class 2,500 to 5,000 francs, and the third class from 1,500 to 2,000 francs. This staff is distributed between the Central Office and the district or Departmental observatories. The staff at stations of the first order consists of a director, two assistants, and an attendant. One of the titular meteorologists has the position of director of the Central Office, and one of the adjuncts or assistants performs the duties of secretary.

The annual budget of the Central Office is about 200,000 francs, which does not include the appropriation for the mountain stations nor for the astronomical-meteorological observatories. Postage and telegraphy (except the agricultural notices) are free.

THE PARK OF ST. MAUR OBSERVATORY.

The Paris observing station of the Central Office was established here in 1880, where observations had been conducted by M. Renou since 1872. The Park lies about 15 km. southeast of Paris, upon high ground almost surrounded by the river Marne. The situation is admirable, but the buildings are mostly temporary and the meteorological apparatus is simple.

M. Ed. Renou is the director, and M. Th. Moureaux has charge of the magnetic observations There are two assistants in the meteorological and one in the .gnetic department. The

appropriation by the Central Office is 12,500 francs for meteorological and about 3,000 francs for magnetic work.

*The Meteorological Instruments and Observations.*—The main building, which is of wood, and was built for the Paris Exhibition of 1878, is not adapted for its purpose. Upon a tower about 3 m. square and 12 m. high are exposed a solar radiation thermometer (black bulb in air), a Campbell-Stokes sunshine recorder, and a wind vane floating on water. A registering attachment to the latter is not in use. For indicating very light winds a streamer floating from a high pole is used. There is no anemometer. On the lower floor is the director's office and the barometers, at a height of 49 m. above sea-level. A large Fortin instrument is the standard, but a Tonnelot-Renou barometer with a fixed cistern is ordinarily used. There are the barographs of Redier and Raymond, with siphon tubes and float recorders. Redier's barograph is much used in France and England. The barometer tube is constantly being raised or lowered along a rack, by clockwork. The movements are controlled by a float in the short arm of the siphon, which by a lever engages one or the other escapement of a differential train as the mercury rises or falls in the tube. Its surface, however, remains at a constant level in space, and by the displacement of the tube motion is communicated to a pencil moving horizontally, which records the height of the barometer in a serrated curve upon a moving roll of paper.

The thermometer shelter stands over sod. It has a double roof, sloping towards the south at an angle of 30°, supported by four posts about 2 m. apart. Under this is a smaller wooden roof, also set on four posts, having screens to intercept the sun's rays on the east and west sides. The screens are of black oilcloth, which is the material of the upper roof. The sides do not extend below the thermometers, which are placed about 2 m. above the ground, and in order to eliminate the heat of the observer's body, they are read by a telescope which is movable, to avoid parallax. Under a similar shelter are a Richard thermograph and hygrograph. The earth thermometers, sunk in the ground, are enclosed in zinc tubes closed at the top and bottom.

The thermometers project from the grass so that they can be read without withdrawal by means of an oblique mirror. One is buried at 30 cm., the other is sunk to a depth of 1 m., and is enclosed in a double tube, so that it can be withdrawn if necessary. To obtain the temperature at the bulb, two thermometers are employed; the shorter, which has no bulb, giving the temperature of the tube, and the difference of readings being the temperature of the bulb. The thermometers are read daily at 10 A. M. and 10 P. M. Terrestrial radiation thermometers are observed at 7 A. M. and 10 P. M.

The receivers of the rain-gauges are placed 1.50 m. above the grass. In the Babinet gauge the water passes from the receiver, which is 20 cm. in diameter, into a collecting cylinder, from which it can be let through a cock into a glass tube having $\frac{1}{10}$th the area of the receiver and divided to 0.1 mm. In winter, night lights are placed on the upper or lower shelf of the case surrounding the gauge, according to the degree of cold. The Richard self-recording gauge has a balance with a double tilting bucket, which empties itself for each centimeter of rain, and records the rate and amount ou a revolving drum. For obtaining cloud directions a horizontal mirror with a circle graduated to degrees, and a movable cone as a sighting point, is used. Observations are made during the day-time of the transparency of the atmosphere, by noting the visibility of objects, whose distance is known, from the tower. Observations are made twice daily of the transparency of the river Marne, by sinking a white porcelain disk and noting at what depth it is barely visible. The temperature of the water is noted at the same time.

Direct observations are made each hour, with the exception of 2 and 3 A. M., for which the values are obtained from the self-recording instruments. Mean time, and not Paris time, is used. The regular series of hourly data is: Amount of clouds, barometer at 0°, wet and dry bulb thermometer, relative humidity, tension of vapor, wind direction and force, solar thermometer. Under "Observations" are recorded the kind and direction of motion of clouds, etc. Each night the records are copied, so as

to have duplicates, which are kept in different buildings for safety. The hourly means are computed separately, from these copies, and they must agree before insertion in the monthly summary, by which errors are eliminated. One of the assistants is on duty from 4 A. M. to 5 P. M.; the other from noon to 1 A. M. Some of the observations are published daily in the *International Bulletin*, and a summary in the *Monthly Bulletin*. The reduced hourly values appear in Vol. I of the *Annals*, for which the *resumé* of 15 years is being prepared by M. Renou.

*The Magnetic Observatory and Instruments.*—The observatory for the study of terrestrial magnetism occupies a special cottage, erected in 1882,— 7 m. in length by 5 m. in width,—the front of which is directed according to the geographical meridian. The cottage, into whose construction and furniture not a particle of iron enters, forms in its elevation a hall occupying the whole ground floor, which serves as an office and for various experiments. The magnetic apparatus is installed in arched cellars, the westerly cellar being appropriated to the direct reading instruments, and the easterly one to the registering apparatus. Facing the staircase is a photographic laboratory. Air vents in the walls secure sufficient aeration to prevent dampness, and the temperature, as shown by a thermograph, is very constant.

Absolute magnetic measurements are made about once a week, to control the indications of the variation instruments. The absolute magnetic instruments are placed on stone pillars outside the building, and comprise a portable theodolite to determine the declination, the horizontal and vertical component of the magnetic force, and a compass for the inclination. These instruments were made by Brunner, of Paris, at a cost of about 4,000 francs, and have been used in a magnetic survey of France and Algeria. The variation instruments are three in number: the declinometer, the bifilar, and the magnetic balance. They are fixed upon masonry pillars whose minimum distance apart is 2 m. The declinometer serves to measure variations in declination, the bifilar for horizontal components of the terrestrial force, and the magnetic balance to measure variations in

the vertical component. They are read by three telescopes placed on a central pillar, at the hours of 8 A. M., 1 and 6 P. M. These instruments were constructed by Carpentier, of Paris, from M. Mascart's designs, at a cost of 2,000 francs. The registering photographic magnetometer designed by M. Mascart differs from the Kew system in its cheapness, in the one source of light for the three instruments, and in the registration of all the elements upon the same paper. The variation instruments, in the dark east vault, are similar to those in the west vault which are read directly. The registering apparatus was constructed by Duboscq, at a cost of 650 francs. It consists of a clock whose pendulum swings in a plane parallel to the magnetic meridian. In front of the clockwork is a lamp, burning 36 hours, with three lenses provided with slits, through which luminous rays reach the declinometer, the bifilar, and the balance. By means of prisms the luminous images of the slits are sent to the sensitized paper, which thus receives six traces, three of these being datum lines of each of the elements, and the three others curves which give their variations. The hour is marked on the paper by having the paper-holder descend 1 cm. per hour between glass plates, whose rulings are photographed on the paper. The time is further controlled by a periodical disturbance of the magnetized needles, caused by passing an electric current near each instrument. This is done by pressing a button in the office eight times a day, or automatically by the clock. Gelatino-bromide of silver paper, which is extremely sensitive, is used, and the different inscriptions which mark the curves are likewise photographed on the sheets, which are changed daily at noon. The instruments have been in operation since 1882. A description of them, and a summary of the observations, was published in the *Annals* for 1884 and 1885.

Atmospheric electricity is observed with the Mascart apparatus. The collecting agency is a stream of water discharging outside a building, from a reservoir within the building, which is heated in winter. The reservoir is connected with an electrometer, whose indications are registered by the photographic apparatus of Duboscq. Filling the reservoir twice a day brings

the potential to zero, and serves to control the time. The curves had not been reduced for publication up to 1887.

THE EQUIPMENT OF THE STATIONS AND THE METHODS OF OBSERVATION.

The mountain observatory on the Pic du Midi, and that on the Puy du Dôme, with its plain station, were described by the writer in the JOURNAL, Vol. II, No. 12. What follows relates to the instruments and observations at the secondary stations reporting to the Central Office. The instruments are there tested before being distributed, and occasionally after installation, when the stations are inspected. At the Central Office the barometers are tested in a double copper cylinder from which the air is partially exhausted, and whose temperature can be altered by water circulating in the double walls. The air pressure is read by a manometer, and the height of the barometers by a cathetometer. Twelve thermometers at a time can be tested in a comparator in which the water is heated by gas and agitated by a stirrer. Generally the thermometers are not tested below 0° C., but some are immersed in ice and chloride of methyl or chloride of calcium, which give temperatures of — 25° to — 35° C.

The barometer generally used is the Tonnelot-Renou, in which the fixed cistern has one hundred times the area of the tube, requiring a tabular correction at each reading except one. In the new Renou barometer the scale itself is compensated. The cost of the instrument is 115 francs; of the Fortin type, 110 francs. The closed cistern barometer suspended on gimbals for use at sea is furnished for 100 francs. The thermometers in use are the wet and dry bulb, forming a psychrometer, which is sold for 30 francs, the maximum thermometers of Negretti (constricted tube), Baudin (air bubble) or Alvergniat (index), and the Rutherford minimum thermometer, costing about 8 francs each. The standard thermometer shelter is similar to that described at the Park of St. Maur; but when only maximum and minimum thermometers are used, they may be exposed under a small triangular metal roof fixed on a post 1.75 m. above the grass. The

use of the sling thermometer to test the exposure is recommended. The hair hygrometer of Salleron or Hermann and Pfister is never to be used alone, but when controlled by a condensation hygrometer of Alluard or Regnault, or by the psychrometer, it may be used advantageously, and in winter it may supersede the latter instrument. The rain-gauges of Babinet or Hervé Mangon, costing 40 and 90 francs, respectively, are mostly used. The former has already been described; in the latter the rain is received in a funnel of 4 sq. dm., from which it enters a tube with a measuring glass. After reading, the water is let by a cock into a reservoir below, and at the end of the month its measurement should agree with the sum of the daily measurements. The gauges are to be placed 1.50 m. above the ground, and never upon a roof. For snow, the method of taking a section is recommended. The Robinson anemometer is commonly employed, sometimes with the Hervé Mangon register.

The hours of observation at the second order stations are generally either 6 and 9 A. M., 12, 3, 6 and 9 P. M., or 6 A. M., 1 and 9 P. M., local time. The third order and rain stations observe once daily, at 7, 8 or 9 A. M. Twenty-six stations formerly made the simultaneous observations corresponding to 7 A. M. and 3 P. M., Washington time. Forty-one stations telegraph an observation at 7 A. M., with that of 6 P. M. of the previous evening, and some of them also an observation at 2 P. M., to the department of Weather Telegraphy.

The instructions to observers are *Instructions Météorologiques*, a second edition of which was issued by the Central Office in 1881, containing reduction tables. The schedules for recording the observations for the different classes of stations are as follows:

The Normal Schools have folio sheets of two different sizes and arrangements, according as the observations are made six or three times a day. The general data required on both schedules are: Kind, maker and number of barometer, its correction, and the altitude of its cistern; numbers of the thermometers.

N. B.—The barometric and thermometric observations are corrected for instrumental errors.

The current observations are:

Barometer: observed, temperature, reduced to 0°.

Thermometer: dry, wet, and difference.

Relative humidity.

Wind by vane: direction (16 points) and force (0–6).

Wind by clouds: lower, upper.

Cloudiness (0–10).

Temperatures: minimum, maximum, mean.

Precipitation (mm. and tenths).

Remarks.

Name of observer.

Monthly means or sums for each observation of these data: Barometer reduced to 0°; dry bulb thermometer; relative humidity; number of times wind blew from each of 16 directions, and calms; number of times sky was clear, partly clear, cloudy, very cloudy and overcast; number of days with rain, snow, lightning, thunder, hail, sleet, white frost, frost, fog and haze; total precipitation; mean of maximum and mean of minimum temperatures. This schedule is to be certified to agree with the register by the director of the school.

The observations made at the third order stations under the supervision of the Meteorological Commission of the Department, are entered upon schedules furnished by the Central Office. They are made out in triplicate, one copy being kept by the observer, the two others certified by the mayor and sent franked to the prefect of the Department. One of these copies remains in the archives of the Commission, the other goes to the Central Office. The schedule is a folio sheet, with the altitude of the station; name of observer and hour of observation; kind, maker, number and corrections of barometer, maximum and minimum thermometer. The observations comprise:

Barometer: observed, attached thermometer, reduced to 0°.

Temperature: morning (from minimum), minimum, maximum.

Rain or snow.

Wind: direction (16 points) and force (0–6).

Direction of cloud-movement.

Cloudiness (0–10).

Remarks.

Supplementary remarks on the general character of the weather, vegetation, thunderstorms, etc. The third page contains instructions to observers.

The schedule for the rain stations is made out and sent to the prefect in the same way as the preceding one. It is a single sheet, with data regarding the altitude of the station above the sea and of the gauge above the ground, and the form of gauge. The observations required are: Morning observations of wind direction and force, cloud direction and amount. In preceding 24 hours: Time, duration and amount of heavy rains; time, duration and total amount of rain. Remarks (snow, frost, etc.). Number of days with rain, snow, thunderstorms, and hail. On the back of the sheet are instructions to the observers.

Another schedule, which is to be sent about December 1st either to the Departmental Meteorological Commission or directly to the Central Office, contains information concerning the dates of the periodic agricultural phenomena, plants, trees and shrubs, observations on animals, etc.

The thunderstorm schedule is to be sent to the prefect of the Department immediately after each storm. It is a single sheet, and provides for the following data for a single storm: Time of commencement, greatest intensity, and end; point of horizon whence it came, and direction in which it disappeared; velocity and direction of cloud movement; force and direction of wind; intensity of lightning; intensity of thunder; intensity and duration of rain; size and duration of hail. [The first and last thunder are taken as the beginning and ending of the storm; the force of the wind, the velocity of the clouds, and the intensity of the rain, thunder, etc., are represented by words or by the figures 1 to 6.] What neighboring Communes the storm passed over; on which side lightning was seen; damage by the lightning, wind, hail, etc. On the back of the sheet are instructions for filling it out.

# THE TOPOGRAPHY AND CLIMATE OF PROVINCETOWN, MASSACHUSETTS.

By John R. Smith.

Provincetown is at the extremity of Cape Cod, and forms the closed hand—minus the thumb and with the forefinger crooked and separated from the inner hand—of the bent arm of Cape Cod, which has the name of the right arm of the State of Massachusetts. Provincetown is about two or two and one-half miles wide (S.S.E.-N.N.W.) and about four miles long (E.N.E.-W.S.W.), exclusive of the crooked finger, which has the name of Long Point, whose end points towards the wrist. This strip of land is not more than one-fourth of a mile wide, but is about one and one-quarter miles long. Within the shelter of the finger and the hand is one of the finest harbors on the whole coast, with a depth sufficient to float the largest ships and with room enough for hundreds of vessels to lie at anchor, sheltered from all storms except the southeast, from which some protection is afforded by the inner forearm just above the wrist. The convexity of the back of the hand between the northwest and northeast portions is noted for its numerous shipwrecks. The beach is strewn with wreckage, and timbers of stranded vessels protrude from the sand throughout its whole length. Bars of sand run parallel with the shore at a distance of about half a mile, with deep water between, and these ridges or bars have been the cause of the loss of many vessels, held on them and swept by waves of enormous size, as that part of the coast is open to the ocean.

The soil of Provincetown supports a vegetation somewhat wonderful for such a soil, and so vastly different from the rest of the Cape as to be remarkable. It seems to me that Provincetown was once an ancient shoal of the sea, having been raised bodily out of it, and then by the action of the winds thrown up into isolated ridges or chains of hills running parallel with its length. Their highest tops are not much over fifty feet, and the valleys between the hills nowhere present a

natural plot of ground of five acres. There are some six or eight ponds of fresh water. The tract of land covered with a vegetable mould of not over six inches in depth, and supporting the natural flora, embraces the southeast half of Provincetown; the rest of the surface, together with the underlying soil, if soil it may be called, is simply and purely sand of a straw color at the surface; no clay or stones are found here, unlike the rest of the Cape, whose soil is clay or clay and sand combined, plentifully supplied with stones of all sizes, some as large as boulders. The change of the soil at this end of the Cape is very abrupt, so much so that it changes from a headland of clayey soil some 75 feet in height to low, clear sand at its foot. The clayey soil of the rest of the Cape renders possible its cultivation at a higher elevation than here, for the sandy soil allows the rainfall to pass too freely through it, and swamp gardens only are cultivated. Fresh water for domestic use is obtained mainly from driven wells, from which a good, inexhaustible supply of water is obtained, even within a stone's throw of the salt water.

The ground destitute of mould is covered with beach grass, averaging one foot in height, which is a troublesome weed to cultivators. A large portion of the ground, which at one time was covered with trees of large size, is now barren of all but the beach grass. The remaining stumps of trees are brought to light by the shifting sand in the severe northwest winter winds, and this sand is now rolling steadily on like a great wave into the woods, carrying on the same destruction. Some of the sand-hills are from 20 to 25 feet high and have an inclination to the horizon of about 60°, with some trees half submerged in the sand and others with their top limbs only above the surface. And it appears that Provincetown is again steadily becoming submerged or settling back into the sea. This is shown by the fact that at extreme low tide (the tide here having a rise and fall of ten feet) stumps of trees are still seen about two feet under water, and others are left bare by the tide, so there are stumps of trees at least twelve feet under water at high tide. still standing erect and firmly imbedded in the sand. They are so changed by the salt water as to be almost unrecognizable, but those fur-

ther inland are in better condition; the ponds also are full of these old stumps.

The climate is mild in the extreme, as compared with the mainland in the same latitude, which is to be attributed to the modifying influence of the surrounding water, for the temperature of the water in winter is warmer than the air, and in summer it is cooler. The extreme range of temperature is some 20° greater on the mainland than at Provincetown, where 0° and 90° are points rarely touched. The mean annual temperature is 48°. The wind is felt to good advantage, and the prevailing direction for the year is southwest. For the several seasons—the seasons being reckoned to correspond with the positions of the sun in the ecliptic, winter from the winter solstice to the vernal equinox, etc.,—the prevailing directions are: winter, N. W.; spring and summer, S. W.; autumn, N. W. and S. W. The mean annual precipitation for five years is 40 inches, but the snow-fall is not so large as on the mainland.

## INCREASE OF RAINFALL.

By Frank Waldo.

The question of increase of rainfall west of the Mississippi is one of great interest, and even before the appearance of the papers on that subject in this journal, I had decided to devote some time to the question, intending, if I should arrive at any definite results to publish some statistical information. With the exception of Professor Hazen's Signal Service Note, in which he discusses the rainfall for a short series of years, no *actual figures* had come to my notice, and of course the statements of the writers who had been dealing with the subject, in a rhetorical sort of a way, could not be accepted as scientific facts unless their results are accompanied by the results of the observations on which their conclusions are based.

Professor Harrington's paper has put the matter in a way easily understood, and while I doubted (and still doubt) the applicability of the method to *so short a series of years* of ob-

servation, yet I am now pretty well convinced that his method is probably as good a one can be carried out. It may be, also, that in transition belts, where the rainfall decreases rapidly, as is the case west of the Mississippi River, the isohyetal lines may have periods of oscillation due partly to the non-concurrence of the phases of the long period inequality for the places having greater and less rainfall, and partly to the difference which may exist in the absolute amplitudes observed during long periods. Of course the greater the number of years of observation, the less this oscillation would be; but for so few years as were at Professor Harrington's disposal, it seems to me not unlikely that the amplitude of this oscillation might be equal in magnitude to the amount of difference found by him in his paper in this journal for December, 1887.

In order to carry on my own *intended* investigation, I applied to the Chief Signal Officer for the annual precipitation for such stations of the west as had been in operation for 35 years. He kindly gave me the data for Fort Leavenworth as being the only one that answered that condition. I at once abandoned the idea of being able to render actual assistance in the matter of making a definite settlement of the question, for a careful study of data covering long periods of rainfall has led me to the belief that less than 35 years' observations would not settle the matter if we are to rely on the change in the absolute average rainfall as being decisive. It has been shown by several writers that there does exist a long period of inequality in the rainfall of most places, and this period is considerably longer than the one usually sought for by most investigators who have compared the rainfall (and every other meteorological phenomenon) with the sun-spot frequency.

If there is a period of from 25 to 40 years during which the annual amount of rainfall descends from a maximum to a minimum and ascends to a maximum again, it is obvious that we cannot compare one short series of years with another short series for the same place unless we know in what phase of the long period curve the times occur. Of course the greatest difference would occur when one series occurred at the maximum

and the other at the minimum of the long period. I think, therefore, that the methods alreudy used for studyiug this question cannot give a satisfactory result until we have a longer series of years of observation. I quite agree with the main objections urged by Professor Curtis in his recent articles in this journal, and especially as to the accuracy of the data used. He has rendered a very important service by his looking up the Fort Leavenworth observations, and there is no doubt but that it will be absolutely necessary for some one to go carefully over the ground, at each station to be used in an investigation of this kind, and see the exact location of the rain gauge, and have pointed out to him the former locations, in order to see if there are disturbing influences or any reasons why two sets of observations at any one place should not be combined. Even in the best observatories there often exist unnoticed vitiating influences, as for instance the growing up of the trees near the rain gauge at the Observatoire Astronomique at Paris.

In order to give a little idea of the long period of the inequality of the rainfall, I will cite the following data, in which are given the mean residuals of five-year periods from the mean rainfall, in millimetres. Table I is from Dr. Wild's "Regen Verhältnisse des Rus. Reiches"; Table II, from Dr. Lang's paper on "Der säculare Verlauf der Wetterung als Ursache der Gletcherschwankungen in den Alpen"; and Table III I have prepared from Signal Service publications, with the exception of Fort Leavenworth, and for this I used manuscript data, kindly communicated to me by the Chief Signal Officer, up to 1870, and from then up to 1884 the results published by Professor Curtis in the American Meteorological Journal, September, 1888.

The cases where the five years were not complete are marked with a *. The times of maximum at the foot of the tables are given in bold type and the minimum in plain type. These times are obtained from a mere inspection of the tables, except for Table II, and here most of the dates were obtained by Dr. Lang from the curves drawn by means of the charted data.

Of course this crude method cannot fix accurately the times

of maximum and minimum, but still the results can perhaps be considered as approximate as the lack of uniformity of the changes will allow; and different persons will probably not agree as to the exact turning points.

In examining these dates we find that the maximum at one station often occurs at the time of a minimum at another; nor is this to be wondered at, for, as Professor Balfour Stewart has somewhere said, we must not expect that these critical points will occur at the same time at places having totally different meteorological conditions. (I do not remember Stewart's exact phraseology.)

For Table III, I have selected stations having about the same latitude, and extending from near the eastern coast to the great plains, in order to get the change of rainfall along the this line; but I cannot see that any deductions can be made from the data. (The data for Marietta and Cincinnati were also desirable, but were not easily accessible.)

For the Tables I, II, and III, I find for the average:

| | Min. to Max. | Max. to Min. | Total Period. |
|---|---|---|---|
| TABLE I......... | 18.5 years, | 19.6 years, | 38 years. |
| TABLE II........ | 20.4 years, | 13.4 years, | 34 years. |
| TABLE III...... | 12.9 years, | 12.3 years, | 25 years. |

This might seem to indicate roughly that the number of years in the period may increase with the latitude (and with decrease of rainfall?).

My main point is to call attention to the fact that this periodic change has not been sufficiently considered in the discussion of the question of change of rainfall, but before closing let me mention the desirability of a study of this same question from some other point of view; as for instance the discussion of the amounts of outflow from the rivers draining the country under consideration,* or the height of water in the lakes; and in Dr. Hann's review of Blanford's paper on "The Effect of Woods on Rainfall" (see *Met. Zeit.*, 1888, p. 236), we find it stated that if

* In Dr. Bruckner's paper, "Die Schwankungen des Wasserstand im ihrer Beziehung zur Witterung," we find for the Mississippi River 1823, 1836, 1845, 1855 (?), 1878 (?); for Lake Michigan, 1856, 1868, 1878. These show a period of something over 20 years.

an increase is noted as due to change of vegetation, this difference must show a steady increase for successive years; so that if we apply this method to our western region we must find that on the average each year shows a slight increase for the western over the eastern stations. This last method has the advantage that it can be applied to a short series of years.

TABLE I.

| Periods. | Warschau. | Astrachan. | Baku. | St. Petersburg. | Helsingfors. | Bogoslowsk. | Katharinenburg. | Slatoust. | Lugan. | Barnaul. | Nertschinsk. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| 1811 — 1815 | —73 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1816 — 1820 | +38 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1821 — 1825 | —72 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1826 — 1830 | —39 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1831 — 1835 | +88 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ |
| 1836 — 1840 | ........ | ........ | ........ | +08 | ........ | +63* | +08 | —57* | +21* | +111* | —58* |
| 1841 — 1845 | —55 | ........ | ........ | +10 | ........ | —10 | —85 | —47 | +70 | +24 | +78 |
| 1846 — 1850 | +27 | —15 | —18 | +06 | —15 | +46 | +125 | —23 | —64 | +40 | +38 |
| 1851 — 1855 | +162 | —05 | +84 | —88 | —67 | +09 | —28 | +98 | —19 | —29 | —53 |
| 1856 — 1860 | +57 | —44 | —20 | —89 | +05 | —33 | —87 | +42 | —22 | —60 | —60 |
| 1861 — 1865 | —46 | —28 | —54 | +22 | —70 | —91 | —70 | —23 | —92 | —107 | —88 |
| 1866 — 1870 | +35 | +12 | —39 | +137 | +41 | —127 | +39 | —71 | +05 | —84 | +16 |
| 1871 — 1875 | —01 | +31 | —01 | +58 | +13 | +92 | +37 | +99 | 0 | +02 | —03 |
| 1876 — 1880 | —27 | +16 | +23 | +89 | +91 | +55 | +57 | +20 | +94 | +92 | +30 |
| 1881 — 1885 | —46 | +21 | —22 | +20 | +75 | +13 | —12 | —46 | +26 | +136 | +117 |
| Av. Rainfall, mm | 659 | 156 | 253 | 474 | 565 | 411 | 356 | 469 | 373 | 257 | 412 |
| | Year. | Yêar. | Year. | Year. | Year. | Year. | Year. | Year. | Year. | Year. | Year. |
| Max. and Min. | 1823 | ........ | ........ | **1843** | ........ | **1846** | ........ | 1841 | **1842** | **1840** | **1845** |
| | **1853** | 1858 | **1853** | 1856 | 1853 | 1866 | 1858 | **1852** | 1861 | 1863 | 1861 |
| | 1883 | **1875** | 1864 | **1870** | **1878** | **1875** | **1876** | 1867 | **1880** | **1883** | **1883** |
| | ........ | ........ | ........ | ........ | ........ | ........ | ........ | **1875** | ........ | ........ | ........ |

TABLE II.

| Periods. | Prague. | Regensburg. | Hohenpeissenburg. | Stuttgart. | Milan. | Vienna. | Munich. | Chioggia. | Reichenhall. |
|---|---|---|---|---|---|---|---|---|---|
| | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. | mm. |
| 1800 — 1804........ | .......... | —55 | +35 | .......... | —56 | .......... | .......... | .......... | .......... |
| 1805 — 1809........ | —46 | +06 | +72 | .......... | —92 | .......... | .......... | .......... | .......... |
| 1810 — 1814........ | —18 | —50 | +70 | .......... | +183 | .......... | .......... | .......... | .......... |
| 1815 — 1819........ | —09 | —67 | —22 | .......... | —111 | .......... | .......... | .......... | .......... |
| 1819 — 1824........ | —45 | —46 | —78 | .......... | —23 | .......... | .......... | .......... | .......... |
| 1825 — 1829........ | —10 | +200 | —90 | —24 | —56 | .......... | .......... | .......... | .......... |
| 1830 — 1834........ | —12 | +103 | +37 | —07 | —100 | .......... | .......... | .......... | .......... |
| 1835 — 1839........ | +20 | +04 | —21 | —02 | +136 | .......... | .......... | .......... | .......... |
| 1840 — 1844........ | +36 | —96 | +103 | +46 | +79 | .......... | .......... | .......... | .......... |
| 1845 — 1849........ | +80 | .......... | —111 | +24 | +141 | —110 | .......... | .......... | .......... |
| 1850 — 1854........ | .......... | .......... | .......... | +65 | +67 | —79 | +61 | .......... | .......... |
| 1855 — 1859........ | .......... | .......... | .......... | —53 | —14 | —68 | —54 | .......... | .......... |
| 1860 — 1864........ | .......... | .......... | .......... | —77 | —03 | —23 | +16 | .......... | .......... |
| 1865 — 1869........ | .......... | .......... | .......... | —27 | —140 | —16 | —36 | .......... | .......... |
| 1870 — 1874........ | .......... | .......... | .......... | —41 | —99 | +15 | —71 | .......... | .......... |
| 1875 — 1879........ | .......... | .......... | .......... | +123 | —26 | +128 | +08 | .......... | .......... |
| 1880 — 1884........ | .......... | .......... | .......... | +71 | +89 | +51 | +79 | .......... | .......... |
| **Av. Rainfall, mm** | 387 | 504 | 585 | 624 | 1032 | 594 | 812 | .......... | .......... |
| | Year. | Year. | Year. | Year. | Year. | Year. | Year. | Year. | Year. |
| Max. and Min. | **1817** | **(1807)** | **1811** | .......... | **1814** | .......... | .......... | **1809** | .......... |
| | 1822 | 1817 | 1825 | 1825 | 1826 | .......... | .......... | .......... | .......... |
| | **1847** | **1828** | **1840** | **1848** | **1848** | 1847 | **1850** | .......... | **1845** |
| | .......... | .......... | .......... | 1862 | 1868 | **1879** | 1871 | **(1876** | 1857 |
| | .......... | .......... | .......... | .......... | **1882** | .......... | **1882** | .......... | .......... |

TABLE III.

| Periods. | Philadelphia. | Portsmouth. | St. Louis. | Ft. Leavenworth. |
|---|---|---|---|---|
| | mm. | mm. | mm. | mm. |
| 1826 — 1830 | — 81 | ........* | ........ | ........ |
| 1831 — 1835 | — 43 | — 64 | ........ | ........ |
| 1836 — 1840 | + 18 | — 23 | — 38* | + 03* |
| 1841 — 1845 | + 86 | + 76 | — 51 | — 30* |
| 1846 — 1850 | + 33 | +175 | +190 | — 48 |
| 1851 — 1855 | — 06 | —127 | + 36 | — 53 |
| 1856 — 1860 | + 74 | 00* | +168 | +152 |
| 1861 — 1865 | + 71 | + 38 | — 08 | —107* |
| 1866 — 1870 | +122 | + 86 | + 36 | + 06 |
| 1871 — 1875 | + 91 | — 46 | — 84 | — 31 |
| 1876 — 1880 | —127 | — 51 | —137 | + 31 |
| 1881 — 1885 | —137 | +122 | — 08 | — 36* |
| 1886 + | — 81* | + 71* | ........ | ........ |
| Av. Rainfall, mm. | 1090 | 1022 | 1059 | 818 |
| | Year. | Year. | Year. | Year. |
| Max. and Min. | 1828 | 1833 | ........ | ........ |
| | **1844** | **1846** | 1842 | **1838** (?) |
| | 1852 | 1853 | **1852** | 1850 |
| | **1869** | **1866** | ........ | **1875** (?) |
| | 1881 | 1876 | 1877 | ........ |
| | ........ | **1885** | ........ | ........ |

# ADDITIONAL FACTS RESPECTING THE LAW GOVERNING THE DISTRIBUTION IN SPACE OF SEISMISM.*

By Richard Owen.

The object of the present paper is to show that the most important earthquakes, as well as the almost synchronous collateral disturbances, occur along the G. C.'s connecting e. a. volcanoes (often antipodal) and running either at right angles to the plane of daily rotation (probably from early segmentation and fissuring due to refrigeration by radiation), or at right angles to the plane of annual revolution, notably along the belt of G. C. "R" (Monte Rosa); also the G. C. which passes through Japan and Sumatra, defining the E. coast of Asia: hence approximately G. C. "A."

## DEMONSTRATION.

If we bring R. under the B. M. we can trace, along a belt or zone, having several degrees of width, the following: o. a. Erebus, e. a. Tangariro (New Zealand), e. a. Topna (Friendly Islands), e. a. Kilauea, the side vent of o. a. Mauna Loa (the summit); o. a. Unalaska and Umnak (Aleutians), e. a. geysers of Iceland, o. a. Hekla, etc., Etna, Vesuvius, etc., with groups of ex. volcs. in Auvergne, Eifel, Hungary, etc.; but, most to the point, e. a. Stromboli, almost antipodal to Tangariro, with Lisbon and Calabria but a short distance away.

On or near the zone of G. C. "A," we find the numerous volcs. of Sumatra and Java (in the latter two e. a., Lamongong and and Semeru (De Lapparent, p. 423), besides Tomboro (Sumbawa) and a host more in Sunda and Molucca Islands.

Almost antipodal, on the W. portion of the Art. Hor., are e. a. Sangay, o. a. Cotopaxi, Antisana, Pichincha, Tunguragua, Pasto, etc., with e. a. Massaya and Izales and disastrous Cosequina (Cen-

* Abbreviations.—For the sake of brevity "seismism" is designed to include all seismic action of volcanoes, geysers, earthquakes reaching the surface, and earth tremors not breaking the crust. B. M = brazen meridian; Art Hor = artificial horizon; G. C. = great circle; "A" = E. trend of Asia; "B" of Africa; "C" of South America; "D" of North America; "E" of Oceanica. Their counterparts, running N. 24° W., are A', B', C', D' E'; e. a = ever active; o. a. = often active; ex. = volcanoes extinct since the historical period; volcs. = volcanoes; Tr. Cap. = Tropic of Capricorn.

tral America), as well as our National Park Geysers nearly on the zone.

The necessary modifications, for the season of the year, can be made by moving the globe in azimuth from our summer solstice, with the Tropic of Cancer at the zenith, until the Tropic of Capricorn is at the zenith. If the catastrophe, say for Europe, occurred in the night, then the globe may be revolved until R. is near the nadir. In all these positions, Stromboli and Tongariro, as antipodes, remain within the B. M.; and the nearly antipodal Sangay and Lamongong are close to the Art. Hor.

An abstract permits the presentation of only a few

PRACTICAL APPLICATIONS.

1. *Great Lisbon Earthquake*, Nov. 1, 1755. In this case we place the W. I. Islands, New England and Sangay under or within the B. M., and bring the Tr. of Capri. (near W. coast of South America) to the zenith. We then find e. a. Tongariro, Topna and Kilauea on the W. part of Art. Hor., while Morocco, Algeria, Portugal, Spain and Iceland are on the E. part of said zone.

Besides all the portions of Europe more or less disturbed by their proximity to Lisbon (especially Brieg, in Switzerland), Sumatra, within the B. M., was violently shaken on Nov. 2 and up to Dec. 3, and even later. On Nov. 16 and 17, renewed disturbance at Lisbon and Gibraltar. On 17th, two violent shocks in New England and Nova Scotia, under B. M. Nov. 21. again at Lisbon. Nov. 22, at Boston. On Oct. 17, 1855, a violent earthquake in Iceland; and on the 19th, Katlegiaa burst into eruption, and continued active until August, 1856. Humboldt says Lisbon shock felt at Martinique, W. I. (B. M.).

2. *Earthquake at Calabria*, Feb. 5, 1783, half an hour after noon. With Calabria under the B. M. and Tr. Cap. at zenith, we find all the greatest disturbances along that G. C. On Feb. 13, Amboyna, on E. of Art. Hor., was shaken; March 6, shocks in Altai Mountains, also on E.; June 1, violent shocks in Iceland and great eruption of Skaptar-Jökull; on June 8, Calabria again; and 15th, Ost-Gothland, Sweden: all under B. M. Calabria

still shaken in 1784; New York disturbed, Nov.; Guatemala, Dec., 1783; Arequipa, April, 1784; Calabria, a few days before and a few days after.

3. *Earthquake at New Madrid*, Jan. 6, 1812. As the valley of the Mississippi and Caraccas (Venezuela) had been much disturbed in the autumn of 1811, we may set the globe with these regions on the E. part of Art. Hor., with Kilauea immediately under B. M., and the Tr. of Cap. at the zenith for our winter. We then find that the places in Europe chiefly noted, as being repeatedly disturbed about the same time, are Janina in Epirus and Macerata in Italy: both exactly within the B. M., somewhat on the under side of the globe.

In the same manner, the globe can be set for all important catastrophes in volcanism. Thus it would appear that the greatest seismic activity prevails along G. C.'s coincident with the axis of daily rotation, especially connecting (often antipodally) ever active vents, and at solstitial periods for land centre; also along G. C.'s coincident with the axis of annual revolution and with the mean trends of continents: marking often the equinoctial colures (for land centre) at Quito and Sumatra.

New Harmony, Indiana.

## CURRENT NOTES.

Results of the First Year's Meteorological Observations on the Sonnblick.* — In this paper Dr. Hann discusses only the average values obtained for most of the elements from tri-daily observations, but he states that Dr. Pernter is engaged on the reduction of the observations made with the self-registering instruments, the results of which will be eagerly looked for. In a preliminary remark concerning the various high mountain observatories, Dr. Hann says concerning the American stations at Pike's Peak and Mount Washington, that although they have been in operation since 1873 and 1872, yet we have only had a few temperature and air pressure means from them. [We must

* "Resultate des ersten Jahrganges der meteorologischen Beobachtungen auf dem Sonnblick (3,095 m.)," von J. Hann. pp. 31. Aus den Sitzungsber. d. kais. Akad. d. Wissen. in Wien. January, 1888.

not forget that Hellmann first detected, in 1875, the inversion of the daily period of the wind velocity at high altitudes by means of a few published hourly wind velocities on Mount Washington.—F. W.] Dr. Hann certainly lost no time in preparing his paper, for we find the observations of December, 1887, contained in the paper presented to the academy on January 5, 1888. As this report of the Sonnblick observations is only a preliminary one, we shall await the appearance of Dr. Pernter's discussion of the hourly observations before presenting the principal results to the readers of the JOURNAL. F. W.

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METEOROLOGY AND DISEASE.—In his address as chairman of the section of state medicine of the American Medical Association, Dr. H. B. Baker emits no uncertain sound as to the relations of meteorological conditions to disease. He says:

"The statistics of sickness and meteorology in Michigan have proved that most of the important diseases are controlled by conditions of the atmosphere. Even such diseases as small-pox and scarlet fever, due to specific causes, have close relations to the coldness and dryness of the air inhaled. This knowledge does not antagonize the importance of isolation and disinfection in such diseases, but it shows why these measures are especially important when the air is cold and dry; and, inasmuch as the virus of those diseases clings for a long time to infected articles, it explains why, unless disinfection is enforced at all times, these diseases tend to break out and spread during the cold seasons of the year. The explanation is found in the fact that nearly every one of the diseases of the throat and air-passages is increased after the inhalation of cold, dry air. Communicable diseases which enter by way of the air-passages thus find at such times a most easy entrance. Consumption is found to follow the same law, increasing after the cold, dry season of the year, and decreasing after the warm, moist season.

"It appears, therefore, that there has been great progress in our knowledge of the relations of sickness to meteorological conditions, so that, in Michigan at least, we are now able to say under what meteorological conditions each one of many of the

most important diseases will increase or decrease in prevalence. The times, or at least the conditions, of the rise and fall of the sickness from these diseases can be predicted in advance with almost as much accuracy as can the recurrence of the seasons. This may seem to you like laying claim to one of the grandest of recent human achievements, but I think the statement is strictly true, and this knowledge of the conditions tending to the occurrence of diseases should aid us greatly in the adoption of measures for their prevention."

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GENERAL GREELY'S "AMERICAN WEATHER."*— General Greely has in this book collected and put in consecutive and available form the results of the labors of our weather service since its formation. This renders the book of decided value to meteorologists, but he has also added to these data explanations of an elementary character, and corresponding data from other parts of the world, thus making the book both easily understood and interesting to the general public. The addition of numerous maps, charts and tables adds greatly to the value of the book.

It is a curious fact that in works on meteorology written by Americans the illustrative facts have been very largely drawn from foreign sources. The meteorologists of India draw their illustrations from India. Those of Russia, France, Germany, Austria, Italy, Great Britain, take their illustrations largely from their own respective countries; but Americans, notwithstanding the enormous accumulation of American material, and also notwithstanding that we have within our limits an almost complete stock of all climates and all weathers, have too often gone abroad for their facts. The distinctive feature of General Greely's book, however, is that it is, as its name indicates, American. But it is not confined to the United States: it extends from the Caribbean Sea to Fort Conger, and the details drawn from the latter station, the nearest to the pole of any meteorological station ever occupied, add greatly to the interest of the work.

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* "American Weather; a Popular Exposition of the Phenomena of the Weather, including Chapters on Hot and Cold Waves, Blizzards, Hailstorms, and Tornadoes." Illustrated with 32 engravings and 24 charts. By General A. W. Greely, Chief Signal Officer, U. S. A. Octavo: xii + 289 pages. New York: Dodd, Mead & Co., 1888.

In the process of the compilation the author arrives at many novel and highly interesting conclusions, which are supplemented by investigations of his own not published elsewhere. We have not space to call attention to all of these, but may note, as illustrations, the annual waves of high pressure (pp. 84 *et seq.*), the periodic fluctuations of temperature in May (pp. 117 *et seq.*), and the map of the average dates of the last killing spring frosts, near the end of the book.

The book is one with which no one interested in meteorology can afford to dispense. It not only offers a body of important facts of easy access to the meteorologist, and furnishes a simple and interesting book for the private student of meteorology to read, but it also supplements the somewhat apocryphal reminiscences of "the oldest inhabitant" in that it gives time, place, and exact facts of the most notable meteorological phenomena of American interest. It is brought quite up to date, including, for instance, so late phenomena as the blizzards of January 11 and March 11-14, of 1888.

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AN AUTUMN EVENING HAILSTORM.—Cold weather hailstorms are very unusual around the Great Lakes. Such a storm, followed soon after by another lighter one, occurred in Chicago on October 18 last. We clip the account of it from the *Tribune*, of that city, of date of the 19th:

"One of the most remarkable hailstorms in this city in many years burst yesterday afternoon at 5:50. Heavy clouds hung low over the city all day, and occasionally there were brief showers. About six o'clock they were seen to hang unusually low and heavily. There was a bright flash, a heavy peal of thunder, and the fusillade of hailstones began. For fully five minutes the unusual spectacle of a dry shower of ice pebbles was witnessed. The stones fell thick and fast, from the size of a pea to large nuts, while not a few were as large as walnuts. The clatter on flagstones, roofs and window-panes sounded like the sharp rattle of a multitude of drums beating a rapid tattoo. The stones bounded and rebounded on the stone walks before they finally rolled into the gutter, where for two hours after the storm they

lay packed thick enough to be scooped up with a shovel. The fall of hail was succeeded by a heavy downpour of rain that lasted ten or fifteen minutes. The storm then ceased as suddenly as it began.

"The street-car horses crouched under the stinging shower for an instant, then plunged and reared, and it was with the greatest difficulty that they could be controlled. Cabmen hastened to drive into alleys in search of partial protection from the storm. Pedestrians rushed into hallways and doorways, and there waited until the hail was softened into rain. The wind, which during the day had been blowing at the rate of thirty to thirty-five miles an hour, died away to a mere breeze, and the hail fell nearly perpendicularly and spent its force on the walks and pavements where it could do least harm. Where the glare of the electric lights fell on the transparent stones as they danced wildly upon the pavement and sidewalks, the effect was well worth seeing. The hail crystals glistened in all the hues of the rainbow. The light flashed through them and was refracted in myriad tints.

"Between 6:30 and 7:30 P. M., while mere drizzle was falling, another thunderstorm burst, and poured down water in floods. The rain fell in perfect torrents, driven by a wind against which neither cab-drivers nor horse-car drivers could stand. The rain and wind combined blinded both men and horses. An express wagon ran into a Blue Island avenue car at Madison and State streets. Umbrellas were absolutely useless. Twice during the rainstorm hail began to fall again — at 7:55 and 8:05 P. M."

The storm was connected with a large depression of the barometer centering at Concordia, in Kansas, according to the Signal Service officer, Mr. E. C. Voss, which was moving eastward. At 12:45 P. M. the barometer at Chicago was at 29.88; at 1 P. M. it was 29.99 — a tenth of an inch rise in fifteen minutes. After that the barometer at Chicago fell steadily but slowly. The wind had been strong from the southeast during the day, reaching 33 miles per hour at 3 P. M., and fell to six during the storms. It had rained the most of the time for 24 hours before the storm.

The Postal Telegraph officials said that the storm was pretty

general throughout the West and Southwest as far as St. Louis, and the Northwest as far as Minneapolis. The hail was local as far as could be learned. There was heavy thunder and lightning at St. Louis during the evening, and in the Northwest during the afternoon. The storm did not extend far east, probably not farther than Cleveland. There was a heavy gale on the Lakes. Considerable damage was done by the hail in the city.

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METEOROLOGICAL OBSERVATIONS AT BRUSSELS.*—In the first part of this paper are given the various hours of observation since January 1, 1833, and the instruments employed. We find that a Kreil barograph was in use from January 1, 1848, to January 1, 1878, when a Van Rysselberghe meteorograph was in stalled, and also a photographic barograph of Ronalds. Since April 1, 1842, a barometer by Ernst has been used for direct observations, with a correction of + 0.46 mm. This is one of the few observatories where the same barometer has continued in use for over forty years, and this instrument will be of use in connecting older series of observations with modern ones, as it has been frequently compared, indirectly, with the standards of other countries.

The extreme barometer heights for Brussels, at sea-level, are 786.7 mm., observed January 17, 1882; and 725.3 mm., observed October 10, 1872. The following tables are given:

For the noon observation the general mean for each month, together with the year of greatest and least average pressures for each month. Means of the daily maximum and minimum for each month, and means of monthly maximum and minimum for each month. Extreme barometric readings, with greatest monthly amplitudes. Diurnal variation. Hours at which the mean reading occurs for each month and the year. Epochs of maximum and minimum in diurnal variation, according to six years' observations. Non-periodic diurnal amplitude. Table of the variability of the barometer from one day to another and one month to another. Number of times when the barometer has ascended

* "Tableaux-Résumés des Observations Météorologique. faites a Bruxelles pendant une Periode de Cinquante Années (1833-1882)." Préparés par M. A. Lancaster. II. Pression de l'Air. pp. 85.

above or descended below certain limits. Periods of successive days when the barometer was above or below a certain limit. Dates of remarkably low and high barometer, with the duration, amount, and change per hour. Extreme values of low and high barometer. The general characteristics of the barometric pressure at Brussels from fifty years' observations. Mean barometer for each day at noon. Mean barometer for five-day periods. Normal barometric curves at Brussels from fifty years' observations, using daily means; also the same, using five-day means. Mean barometer by months and years, according to the noon observations, for fifty years, for each year and decades. Absolute annual maximum and minimum, with dates for each year. Arranged under each month is given, for each year the mean height at noon, absolute maximum and minimum, and date. Also under each month is given the mean values, for each day of the month, of the average barometer reading, as well as the greatest and the least barometer reading.

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Royal Meteorological Society.—The usual monthly meeting of this Society was held on Wednesday evening, the 19th of December, at the Institution of Civil Engineers, 25 Great George Street, Westminster; Dr. W. Marcet, F. R. S., President, in the chair.

Dr. G. Adkins, Mr. T. M. Blake, Mr. C. J. Bromhead, Dr. A. Newsholme, Dr. E. P. Thurstan, Rev. Dr. T. T. Wilkinson, and Dr. F. M. Williams, were elected Fellows of the Society.

The following Papers were read:

(1) "On the Prolonged Spell of Cold Weather from September, 1887, to October, 1888," by Dr. C. Harding, F. R. Met. Soc. During the fifty-nine weeks ending the third week in October, there were but four warm weeks in the northwest of England, and only five warm weeks in the southwest of England, while in the latter district there was not a single warm week between March 12th and October 22d. The mean temperature for the whole period was dealt with for the twelve districts into which the Meteorological Office divides the whole area of the United Kingdom, and with the single exception of the north of Scotland the weather for the period ending in October this year was

the coldest of any during the past ten years. At Greenwich the temperature during the fourteen months was below the average on 312 days out of 427, or 73 per cent., and in July there was not a single warm day, the temperature being continuously below the average from June 27th to August 6th. The means for July 11th and 12th were colder, by several degrees, than those for March 9th and 10th.

(2) "Report on the Phenological Observations for 1888," by the Rev. T. A. Preston, M. A., F. R. Met. Soc. Vegetation was generally backward throughout the season. In the southwest of England and south of Ireland plants were earlier than usual, but not elsewhere. In February they were from one to four weeks later, and gradually gained ground till June. In the south of Ireland they were slightly in advance of the average in June and July; in the southwest of England they just reached the average in July; whilst in Guernsey they were a fortnight later. Fruits generally were a failure; very few really ripened, and from want of sun were deficient in flavor. Haymaking was unusually late (as much as five weeks); it began in July or August, and was not entirely finished till late in September; much hay was spoilt, or secured in bad condition. Straw was plentiful, and though the corn was not an average crop, the fine October enabled farmers to secure a better one than could have been expected. Roots were often a failure, and potatoes were much diseased.

(3) "A Winter's Weather in Massowah," by Capt. D. Wilson-Barker, F. R. Met. Soc. This gives the results of four hourly observations during December, 1887, to February, 1888; the highest shade temperature was 95° and the lowest 68°.

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MICHIGAN STATE BOARD OF HEALTH. — The Secretary of the State Board of Health has issued his fifteenth annual report (for 1887). The first part is taken up with an abstract of the work of the Board during the fiscal year, and includes the remarks made by the members of a committee of the Board before the Regents of the University, urging the necessity of a laboratory of hygiene at the State University.

The second part of the report consists of eleven papers, abstracts, and reports.

Probably the most important part of this report may be divided into two general heads: the first quarterly report of the Michigan State Laboratory of Hygiene, by Professor Victor C. Vaughan, M. D., Ph. D., Director of the Laboratory, and the Study of the Causation of Diseases, by Henry B. Baker, M. D., Secretary of the Board.

Prof. Vaughan's investigations with tyrotoxicon are treated of in an article by him on "The Chemistry of Tyrotoxicon: Its Action upon Lower Animals; and its Relation to the Summer Diarrhœas of Infancy." This article gives the experiments by which the identity of tyrotoxicon and diazobenzol is established, and contains rules for the prevention of the formation of tyrotoxicon in milk, and the prevention of cholera infantum and summer diarrhœas.

Dr. Baker's studies of the causation of disease are contained mostly in three articles: (1) Principal Meteorological Conditions in Michigan in 1886; (2) Contributions to the Study of the Causes of Sickness,—a statistical report based on weekly reports of sickness in Michigan during the year 1886 and preceding years; and (3) a paper combining these two lines of study, and entitled "The Causation of Cold Weather Diseases." This important paper includes a study of the principal diseases of the air-passages and those communicable diseases which are most prevalent in cold weather. Over 41,000 weekly reports of sickness, and over 100,000 observations of atmospheric temperature are gathered together in tables and graphically represented in diagrams showing that diphtheria and scarlet fever follow inversely the curve for temperature. Similar large numbers of facts are grouped together in the same way, showing that influenza, tonsilitis and bronchitis are related to the atmospheric temperature in the same way—rising as the temperature falls and falling as the temperature rises.

Dr. Baker states the facts which lead him to believe that the non-volatile salts of the blood exuded in excess into and upon the mucous surfaces of the air-passages are capable of causing

an inflammation which is called "influenza," "tonsilitis," or "bronchitis," according to the portion of the respiratory tract involved. Other things being equal, the non-volatile salts are left by evaporation on the mucous lining of the air-passages, in proportion to the dryness of the air inhaled. Inasmuch as the absolute dryness of the air ordinarily depends upon its coldness, the inflammations of the air-passages should be expected to rise as they do after the cold, dry weather, and fall after warm, moist weather. The reason why the communicable diseases increase after the cold months is believed to be because of the greater susceptibility of the air-passages in those months, and this is the reason why the curves representing the rise and fall of these communicable diseases follow the curves for influenza, tonsilitis and bronchitis.

A report by J. H. Kellogg, M. D., on "Dangers in Gasoline" embodies facts collected by him, including the views of leading insurance agents, etc., concerning the dangers in the use and storing of gasoline, and giving rules to be observed in handling this substance, declared to be "more dangerous than gunpowder."

Among the most concise articles in the report may be mentioned the President's annual address, by Hon. John Avery, M. D., which gives a good presentation of the work of the Board in the past, a forecast of its future work, and the economic value of public-health work.

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PHOTOGRAPHS OF LIGHTNING.—The first report of the thunder-storm committee of the Royal Meteorological Society has been issued. It is interesting aside from its scientific value, to the general reader, in that it deals with a new and fascinating method of attacking problems of atmospheric electricity.

About 60 photographs of lightning flashes were received by the society, in answer to an invitation extended in June, 1887; and these were exhibited at a meeting of the society held in March of last year. These photographs were received from all parts of the world and it is extremely gratifying to note the large number received from America.

The tone of the report is one of marked conservatism and there is no attempt to give us the why and wherefore that lightning should assume so many different appearances. The result of the society's efforts however, is the establishment of a great deal of evidence, in accord with which any theorizing we may wish to indulge in, will have to be.

Without doing more than generalizing, it appears that lightning flashes, or better, discharges of an electrical nature in the air, are of many different appearances. Of these different types, the Report notes these as most prominent:

1. *Stream* lightning, or a plain, broad, rather smooth streak of light.

2. *Sinuous* lightning, when the flash keeps in some general direction, but the line is sinuous, bending from side to side in a very irregular manner. In this, it is noticeable that the thickness of the line varies during the course of the discharge. Sometimes the thinnest part of the white streak is the highest, and the flash appears to get thicker as it approaches the earth; at other times, a flash in the air begins thin, broadens out in the middle, and fines away again at the further extremity. The Committee offer no explanations at present, but call attention to the fact that in some photographs of electric sparks taken from an induction coil those of high tension are thinner than those of low tension.

3. *Ramified* lightning, in which part of the flash appears to branch off from the main streak, like the fibres from the root of the tree.

4. *Meandering* lightning.

5. *Beaded or chapletted* lightning.

6. *Ribbon* lightning.

The Committee have not yet in their possession any conclusive evidence as to whether the *same* flash may be normal (*sic*) in one portion and ribboned in another portion of its course. Here is a chance for our photographers. We understand of course that only two directions can be shown on the plane of the plate or paper, while a flash of lightning we have reason to believe is a movement in space, and not confined to two dimen-

sions. Herein, too, may rest the explanation of the apparent thickening of the flash in certain parts of its path.

The Committee do not intend, it is to be hoped, to stamp the terms above used, as class names upon different appearances of a lightning flash, but use these various terms merely as an aid in description. Otherwise, we might soon have established a nomenclature for lightning flashes as involved and confusing as the older cloud nomenclature.

One anomalous appearance is recorded where the photograph shows five ordinary white flashes and one dark streak of precisely the same character as the bright streaks. A purely mechanical explanation is offered, attributing it to an intense flash and resulting over-exposure, but this should not be allowed to pass unchallenged, as we may find there are really *dark* flashes, that is, a flash of such character as to affect the plate in this manner. We have met with dark areas in luminous flames.

We cannot let the opportunity pass, of calling attention to an admirable suggestion of Doctor Oliver J. Lodge,* on the use of a rapidly moving camera in photographs of this nature. "A camera revolving at any ordinary pace would probably give each single flash unaltered, and might also analyze multiple and complex flashes into their constituents."

"One good method, if not too troublesome, would be to arrange a double camera with component axes parallel, so as to photograph the same flash in both halves, but with the sensitive plate in one fixed and in the other rapidly revolving."

The writer wishes to suggest to photographers the great desirability of photographs of aurorae and the commoner forms of heat lightning. Though lacking at first glance the attractive features of the more pronounced forms of electrical discharges, they will be found in the long run the more interesting and valuable, just as they will prove most troublesome to obtain.

The photographic reproductions and autotypes accompanying the report of the Royal Society's committee enhance greatly its interest and worth. The report was drawn up by the Hon. Ralph Abercromby.

A. M.

* *Nature*, July 12, 1886.